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Smart Mixes and the Challenge of Complexity

Lessons from Global Climate Governance

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3.1 INTRODUCTION

Addressing global environmental challenges in the twenty-first century, from biodiversity loss to climate change, requires more than intergovernmental agreements. As has been widely observed, command-and-control instruments have been complemented by a variety of new governance instruments across different issue areas and sectors.[1] The resulting institutional architecture of global governance has been described using concepts such as 'fragmegration',[2] 'assemblages',[3] 'bricolage'[4] or 'new medievalism'[5] to make sense of the seeming complexity of world politics. At the level of concrete institutional arrangements and governance instruments, scholars have noted (international) 'regime complexity',[6] defined as 'the presence of nested, partially overlapping, and parallel international regimes that are not hierarchically ordered'.[7] As a consequence of increased institutional density and overlap, authors have theorised the 'fragmentation of global governance architectures'[8] and the emergence of related 'regime complexes'.[9] However, while complexity is often assumed and hypothesised, few authors have attempted to conceptualise and measure complexity from the perspective of complexity theory. This seems particularly relevant when taking into account the idea of 'smart mixes' and 'smart

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1 Pattberg and Stripple (2008); Jordan et al. (2018).
2 Rosenau (1990).
3 DeLanda (2006); Sassen (2006).
4 Mittelman (2013).
5 Friedrichs (2001).
6 Drezner (2008); Hafner-Burton, Kahler & Montgomery (2009); Orsini, Morin & Young (2013).
7 Alter & Meunier (2009).
8 Biermann et al. (2009).
9 Raustiala & Victor (2004); Keohane & Victor (2011).

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regulation'. These concepts describe an ideal situation in which we can combine various regulatory and governance instruments, both public and private and both international and local, into sophisticated mixes of complementary instruments and actors, tailored to the specific needs of the situation. However, does rational mixing and orchestrating work in situations where the parts of the system (the regulations, policies, institutions) interact in a non-linear, non-additive way to produce unexpected outcomes?

In this chapter, we analyse in what respects the governance architecture of climate change has properties of a complex system. We argue that potential emergent behaviour of complex climate governance, i.e. unforeseen impacts and unintended consequences, might stand in the way of attempts to better manage and orchestrate the many parallel initiatives that have sprung up in recent years next to the United National Framework Convention on Climate Change (UNFCCC). In other words, we critically engage with the concept of smart mixes from a complexity perspective. Rather than arguing that the idea of smart mixes and complex systems do not go together, we think it more useful to explore how a more experimental mode of governance might be utilised to improve the 'smartness' of existing institutional mixes at the global level. This chapter is organised as follows: in Section 3.2, we provide a short introduction to complexity theory and the notion of complex systems. We also operationalise the concept of a complex system for researching the global climate change governance architecture. Section 3.3 then provides an empirical illustration of our claim that the climate change governance architecture has some properties of complex systems. Finally, in Section 3.4 we conclude with outlining some lessons learned and developing a research program on governance complexity and smart mixes for the future.

3.2 COMPLEXITY THEORY, COMPLEX SYSTEMS AND HOW TO STUDY CLIMATE CHANGE GOVERNANCE

This section introduces basic ideas of complexity theory, elaborates further on the properties of complex systems and suggests a way to test whether global climate change governance has properties of a complex system.

3.2.1 *Complexity Theory and Complex Systems*

Next to the widely applied term *complexity science*, scholars use *complexity theory* to refer to a number of assumptions about and perspectives on complexity and complex systems. It is important to note that no general theory of complexity has so far emerged that would be able to explain all classes of complex phenomena, such as hurricanes, financial crises, cities, organisational ecologies and regime complexes. Complexity theory should therefore be understood less as a unified explanatory theory and more as an ontologically founded framework of analysis.

In this chapter, we employ complexity theory to analyse those phenomena that arise from and are visible in complex systems. But what are complex systems? A straightforward way to understand them (if such a thing exists in the context of complexity) is to say that the whole is greater than the sum of its parts. As a result of systemic interactions (to quote Kavalski), 'alterations occur whose outcomes are wholly unexpected and nearly impossible to predict'. [10] A complex system approach considers actions of agents (e.g. organisations/members to governance institutions) that produce macro-level phenomena by aggregation. Sometimes complex systems create complexity. For example, the global financial system is a complex system that has parts that are predictable while other parts have emergent properties, i.e. properties that do not fully derive from the simple sum of all individual parts. Bicycles and pendulums are examples of simple systems; the immune system and ecosystems are examples of complex systems.

We follow Byrne and Callaghan[11] and Bousquet and Curtis[12] in suggesting that most theorists of complexity agree upon the following concepts as key ingredients to complexity theory: non-linearity, emergence, self-organisation and open systems.

In linear systems, when the value of a causal element changes, we can predict the change in the value of the dependent element. The changes in the latter are proportional to the changes in the former. As Byrne and Callaghan note, 'Linearity is foundational to "Newtonian" science by which we mean scientific accounts in which we can describe a current state in terms of values of parameters and have a covering law, a universal/nomothetic specification, which describes how the state will change if values in the parameters change'. [13] Non-linear systems do not satisfy the superposition principle by which outputs are proportional to inputs. In other words, in non-linear systems, effects emerge that are disproportionate to the changes in the input and thereby might be qualified as 'surprising' and hard-to-predict.

What follows from non-linear dynamics is that often we can speak of emergent properties and phenomena that are qualitatively different from those of the individual units/agents that are aggregated (think of the difference between water molecules/water and brain cells/consciousness). Emergent properties are defined as the 'intricate intertwining or interconnectivity of elements within a system, and between a system and its environment'.[14] A good example is a group of commuters competing for space on a road and causing a traffic jam. While the individual commuter is motivated by a simplistic goal, to get home as soon as possible, the aggregate phenomenon, a traffic jam, is hard to predict, evolve and manage. It represents, in other words, an emergent phenomenon.[15]

10 Kavalski (2007), at 437.
11 Byrne & Callaghan (2013), at 8.
12 Bousquet & Curtis (2011).
13 Byrne & Callaghan (2013), at 18.
14 Mitleton-Kelly (2000).
15 See Johnson (2009).

Different from the observed emergent phenomenon, self-organisation is a process 'by which the autonomous interaction of individual entities results in the bottom-up emergence of complex systems'.[16] That means that emergent phenomena do not result from the operation of an 'invisible hand', central agency or intelligent designer. Applied to the field of governance studies, this implies that central steering of entire governance systems is difficult to observe in reality.

Finally, complex systems are usually open systems, i.e. they have porous borders and exchange information and energy with their environments. It is, however, an empirical question how open they are.[17] The assumption of openness contradicts most analysts of political systems, who posit that these are closed: 'disturbances are temporary and the system tends to return to equilibrium'.[18]According to Walzian Structural Realism, for example, the international system does not change in its fundamental features as anarchy and sovereignty construct the conditions of a closed system. Similar assumptions about closed systems can be found in Luhmann's Modern Systems Theory.

In sum, complexity theory assumes that non-linear relationships will dominate complex systems, that equilibrium is not automatically a preferred system state, that self-organisation and emergence are defining properties of complex systems and that, consequently, reductionist approaches are ill-suited for analysing many real-world phenomena.[19]

3.2.2 *How to Study Climate Governance as a Complex System*

To study global climate governance from a complexity perspective, we need appropriate methodologies. Social network analysis provides a particularly suitable approach because non-linearity is a key characteristic of complex systems, and networks are a perfect embodiment of non-linearity. In the words of Capra:

> The first and most obvious property of any network is its non-linearity — it goes in all directions. Thus the relationships in a network pattern are non-linear relationships. In particular, an influence, or message, may travel along a cyclical path, which may become a feedback loop. The concept of feedback is intimately connected with the network pattern. [20]

What follows from this is that network theories and relational ontologies[21] will feature prominently as an analytical tool to unravel complex systems.[22] While

[16] Bousquet & Curtis (2011), at 47.
[17] Singer (1971), at 13.
[18] Harrison & Singer (2006), at 47.
[19] Kavalski (2007); see also Rosenau (2003).
[20] Capra (1996), at 82.
[21] On the notions of relational ontologies and relational thinking in sociology, see Emirbayer (1997).
[22] Watts & Strogatz (1998).

networks as a specific mode of organisation (opposed to markets and hierarchies) have been recognised in International Relations and global governance scholarship for a while,[23] network analysis as a formal method of inquiry has been applied less frequently. This is rather regrettable, as network analysis allows for fine-grained but robust measurements of structure (e.g. interactions among institutions in the climate change regime complex). Network analysis is grounded in three principles that make it an ideal approach within complexity science:[24] first, nodes (i.e. agents) are behaviourally interdependent; second, ties between nodes can be channels for resource exchange (material and non-material); and third, repeated and persistent patterns of interaction among nodes create structures that exert influence on the behaviour of agents. We will utilise these insights in our application of network analysis to the climate change governance architecture in Section 3.3.

But how can we empirically verify whether the institutional structure visible in the climate governance architecture[25] constitutes a complex system? Following Page,[26] we focus on four properties of complex systems with the potential to generate complexity. First, complex systems consist of diverse entities; second, the entities interact in an interaction structure; and third, the behaviour of the entities in the system is interdependent (meaning that they influence each other). We add the criterion of open system as a fourth property, arguing that climate change as a governance system should be open to its environment for our assumption about climate change as a complex system to hold. Adaptation and learning are sometimes mentioned as an additional characteristic; however, due to data limitations, we do not analyse learning effects in this chapter.

In sum, we have argued in this section that complexity theory provides a potentially innovative perspective on global governance in that it allows to study governance systems (aggregations of regulations, institutions, rules, norms, decision-making procedures) as complex systems. Complexity – with its key attributes non-linearity, emergence, self-organisation and open systems – is a possible state of complex systems. Section 3.3 illustrates our claim that the climate change governance architecture,[27] also referred to as the regime complex for climate change,[28] has attributes of a complex system and should therefore analytically be treated as such.

[23] An example is Keck and Sikkink's concept of transnational activist networks; see Keck & Sikking (1998).
[24] Hafner-Burton, Kahler & Montgomery (2009), at 562.
[25] See governance triangle in Figure 3.1.
[26] Page (2015), at 24–25.
[27] Biermann et al. (2009).
[28] Keohane & Victor (2011).

3.3 ANALYSING GLOBAL CLIMATE GOVERNANCE AS A COMPLEX SYSTEM

The complexity of complex systems derives from the relationships among constituent parts, not from the parts themselves. In other words, complex systems are complex because of the interactions of their components and not because of additive effects of all parts. It is therefore not sufficient to map all governance institutions in the climate change regime complex in order to deduce outcomes; in fact, interactions among constituent parts, including feedback loops and non-linearity, result in system-wide, emergent properties. The implications for the idea of 'smart mixes' is potentially far-reaching. If the interaction of the many policies, governance arrangements and institutions operating within an issue area (as possibly between issue areas as well) produces unintended and unforeseeable effects, this might severely limit the ability of actors to engage in a rational design of broader governance architectures.

This section presents an empirical illustration of global governance as a complex system using climate change as an issue area for the case, where increasing institutional density has long been observed and analysed under headings such as 'interplay'[29] and 'fragmentation'.[30] Still, research has only recently started to map and partially measure the overall institutional structure of global governance, i.e. the clusters of norms, principles, regimes and other institutions generally referred to as the *governance architecture* of an issue area. In the words of Biermann and colleagues: 'Most research on global governance has focused either on theoretical accounts of the overall phenomenon or on empirical studies of distinct institutions to solve particular governance challenges'. [31] An important step towards analysing the macro-level of governance institutions in world politics was Raustiala and Victor's conceptualisation of *regime complexes* as 'an array of partially overlapping and non-hierarchical institutions governing a particular issue-area'. [32] While firmly rooted in a state-based, international ontology, their interest was in understanding institutionalisation beyond single regimes and clearly demarcated legal boundaries. Keohane and Victor[33] applied the regime complex conceptualization to climate governance, also with a focus on international cooperation.[34]

[29] Oberthür & Stokke (2011).
[30] Biermann et al. (2009).
[31] Biermann et al. (2009), at 14.
[32] Raustiala & Victor (2004), at 279.
[33] Keohane & Victor (2011).
[34] For an alternative conceptualisation, see Orsini, Morin & Young (2013), at 29: 'a network of three or more international regimes that relate to a common subject matter, exhibit overlapping membership, and generate substantive, normative, or operative interactions recognized as potentially problematic whether or not they are managed effectively'.

Building on, *inter alia*, Young's early work on institutional linkages,[35] the regime complex literature problematises and nuances our understanding of structure in global governance, situating regimes on a continuum, ranging from fully integrated institutions regulated via top-down authority, to nested regimes (semi-hierarchical), and collections of loosely coupled institutions (regime complexes) to fragmented institutional structures that lack coordination and linkages among constituent parts. Consequently, scholars have suggested that regime complexes are inherently complex and therefore justify speaking of *regime complexity*.[36] However, system-wide complexity of governance architectures has been more often assumed than measured. Improving the mapping of institutional diversity might provide further empirical insights into the structure of global governance, in particular understanding its characteristics as a complex system.

When mapping the wide array of institutional forms in global climate governance, Abbott employs a 'governance triangle'.[37] Institutions are situated in the governance triangle depending on the identity of their constituent actors – State, Firm or Civil Society Organisation (CSO) – or combinations thereof.[38] The placement of an institution is determined by judging each actor group's approximate 'share' in the governance of the scheme: in principle, the *State* category includes individual states and collections of states or international organisations (IOs) along with public bodies below the level of central states, e.g. cities and regions. Similarly, the *Firm* category includes individual business firms, groups of firms and industry associations; and ultimately, the CSO category includes individual CSOs as well as CSO coalitions and networks. All three actor groups are defined broadly, so that between them they encompass virtually all possible participants in transnational governance. The triangle is further divided into seven *zones*, which represent the major combinations of actor *types*. Institutions in the vertex zones (1–3) are dominated by a single type of actor; those in the quadrilateral zones (4–6) involve two types of actors; and those in the central zone (7) involve actors of all three types. Additionally, the two dashed horizontal lines divide the triangle into three 'tiers', defined by the nature of government involvement – *state-led* (public institutions are dominant), *private-led* (Firms and CSO are dominant), and *hybrid* (government bodies share governance with firms and/or CSO in public-private partnerships).

Figure 3.1 shows an updated and altered version of Abbott and Snidal's governance triangle applied to global climate governance, including a total of eighty-nine international and transnational governance institutions (updated as of January 2017). Criteria for inclusion in our dataset (1) have been international or transnational, (2) display intentionality to steer the behaviour of their members, (3) explicitly mention

[35] Young (1996).
[36] Orsini, Morin & Young (2013).
[37] See Abbott (2012); Abbott & Snidal (2009); Abbott & Snidal (2010).
[38] Abbott & Snidal (2009).

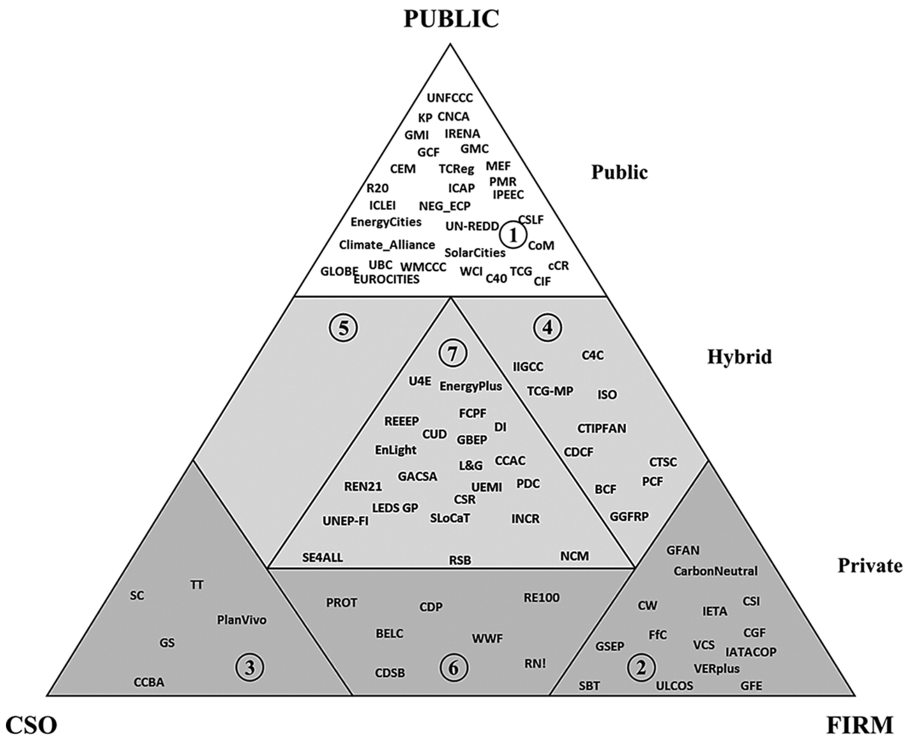

FIGURE 3.1: Global climate governance triangle
(Widerberg, Pattberg, and Kristensen 2016; based on Abbott and Snidal 2009; Abbott 2012).

a common governance goal, and (4) have identifiable governance functions (for further information on selection process, see the technical report by Widerberg, Pattberg, and Kristensen).[39] In the following text, each of the four properties discussed in Section 3.2.2 is analysed using data from the CONNECT-project as outlined previously.

3.3.1 *Diversity*

Complex systems consist of diverse entities (or agents in the parlance of agent-based modelling). Analysing a complex system thus requires a description of this diversity. Mapping the climate regime complex using the heuristic of a governance triangle (see Figure 3.1) reveals seven different zones of interaction determined by the type of actors involved: public actors (e.g. national or local governments); for-profit actors (e.g. corporations); and non-profit actors (e.g. non-governmental organisations). Within these three different broad actor types, we find both diversity (distinct types)

[39] Widerberg, Pattberg & Kristensen (2016).

and variation (distinctions within a type).[40] In terms of member types, the CONNECT-dataset identifies about 10,750 different organizations with different degree of governing functions in the institutions. These can further be divided across six categories: cities (81 per cent), companies (14 per cent), NGOs (3 per cent) and States (2 per cent). The distribution of members across institutions also differs widely, from institutions with one member to those with over 6,000 members. With an average of 142 members, a median of 25 members per institution, and a standard-deviation of 670, however, we observe that while the vast majority of institutions have fewer than 100 members, their size varies considerably. Moreover, institutions in our dataset perform a wide range of functions across a diverse set of themes. We have identified twelve themes: Carbon pricing and trading, CCS, Climate finance, Energy access, Energy efficiency, Forest mitigation (general), MRV, Non-CO_2 GHGs, Renewable energy, Sectoral (e.g. steel, transport, aviation and lighting) and Urban climate action. This finding corroborates previous research by (for example) Bulkeley and colleagues,[41] who study sixty transnational climate governance institutions and identify twenty-one different climate related themes. Hence, we can observe large diversity across the institutions. Zooming in on individual institutions, we also find large variation. For instance, consider city size in the Covenant of Mayors, which, with over 6,000 members, is by far the largest institution in the CONNECT dataset. The distribution ranges from villages such as Isuerre, located in northern Spain, with a population of fewer than 40, to cities such as London, with its population of nearly 8 million. Moreover, the median population of 5,476 in cities that are members of the Covenant of Mayors, and the standard-deviation of over 170,000 (indicating a highly positively skewed distribution) are both similar to the distribution of size of institutions in terms of members.

In sum, the global climate governance regime complex consists of a highly diverse set of institutions and organisations in terms of type, size and thematic focus. For example, even considering only type and theme of institutions generates eighty-four possible institutional types,[42] indicating that the system fulfils the attribute of 'diversity'. Interestingly, the distributions in terms of size in each of the preceding cases are positively skewed. According to Page,[43] these patterns are common in complex systems and allow for testing several explanatory models for this observation. For instance, perhaps we can explain the characteristics of the Covenant of Mayors by a 'preferential attachment' model – suggesting that popular nodes in a network tend to become disproportionally more central than less popular nodes – creating scale-free networks characterised by power-laws.[44] Hence, simply by describing the diversity in the global climate regime complex, and placing it in a complex systems framework,

[40] Page (2015), at 35.
[41] Bulkeley et al. (2014).
[42] 12 themes x 7 zones.
[43] Page (2015), at 34–35.
[44] Barabási & Albert (1999).

we allow for new hypotheses to be generated around the structure of global governance by borrowing concepts from complexity theory.

3.3.2 *Interconnectedness*

Emergent properties of a complex system can only be understood when analysing the interactions among the system's diverse entities. Entities (agents) interact with each other in a networked structure, allowing for non-linear and recursive behaviour to appear. Hence, to understand interaction in complex systems, we need to describe the structure in which the interaction occurs. Starting with the eighty-nine institutions presented in the previously mentioned governance triangle (see Figure 3.1), we have identified two different types of interlinkages – shared members and hyperlinks between homepages – as proxies for interaction.

A membership network is created by connecting those institutions that share members.[45] For example, if the Netherlands is a member to the UNFCCC and the Renewable Energy and Energy Efficiency Partnership (REEEP), then a link is created between the UNFCCC and REEEP. Figure 3.2 depicts the full membership network representing eighty institutions since nine institutions do not share members with other institutions. The nodes are coloured by zone (see also governance triangle in Figure 3.1).

The membership network illustrates the intricate structure of the climate governance complex, as well as how the institutions are by no means 'governance islands' working in isolation from each other, but are in fact quite densely connected across zones in the governance triangle. A particularly dense cluster appears around those institutions with public members, primarily states, such as the UNFCCC, CIF and IRENA. The membership network also shows signs of 'small-worldliness'[46] with a high clustering coefficient and small average path length compared to random graphs.[47] Small-world network topologies can have a range of implications on the system such as the speed of contagion in the network, something which could become important when trying to spread ideas, know-how and information.

The second network connects institutions via hyperlinks. Nearly all institutions in the CONNECT dataset have dedicated homepages providing different types of information, including embedded hyperlinks referring to other institutions and organisations. By linking in this cyberspace, institutions and organisations reveal existing or desired virtual connections. For instance, if an institution links to the UNFCCC homepage on its site, it may consider information on the UNFCCC homepage relevant for its own members and participants. Hyperlink Network

[45] See also Widerberg (2016).
[46] Watts & Strogatz (1998).
[47] The statistics for the random graph were produced taking averages of a 1000 Erdos-Renyi model-runs with the same node and edge count as the observed graph. Small-worldliness is defined as $C_{actual} / C_{random} > 1$ and $L_{actual} / L_{random} \approx 1$.

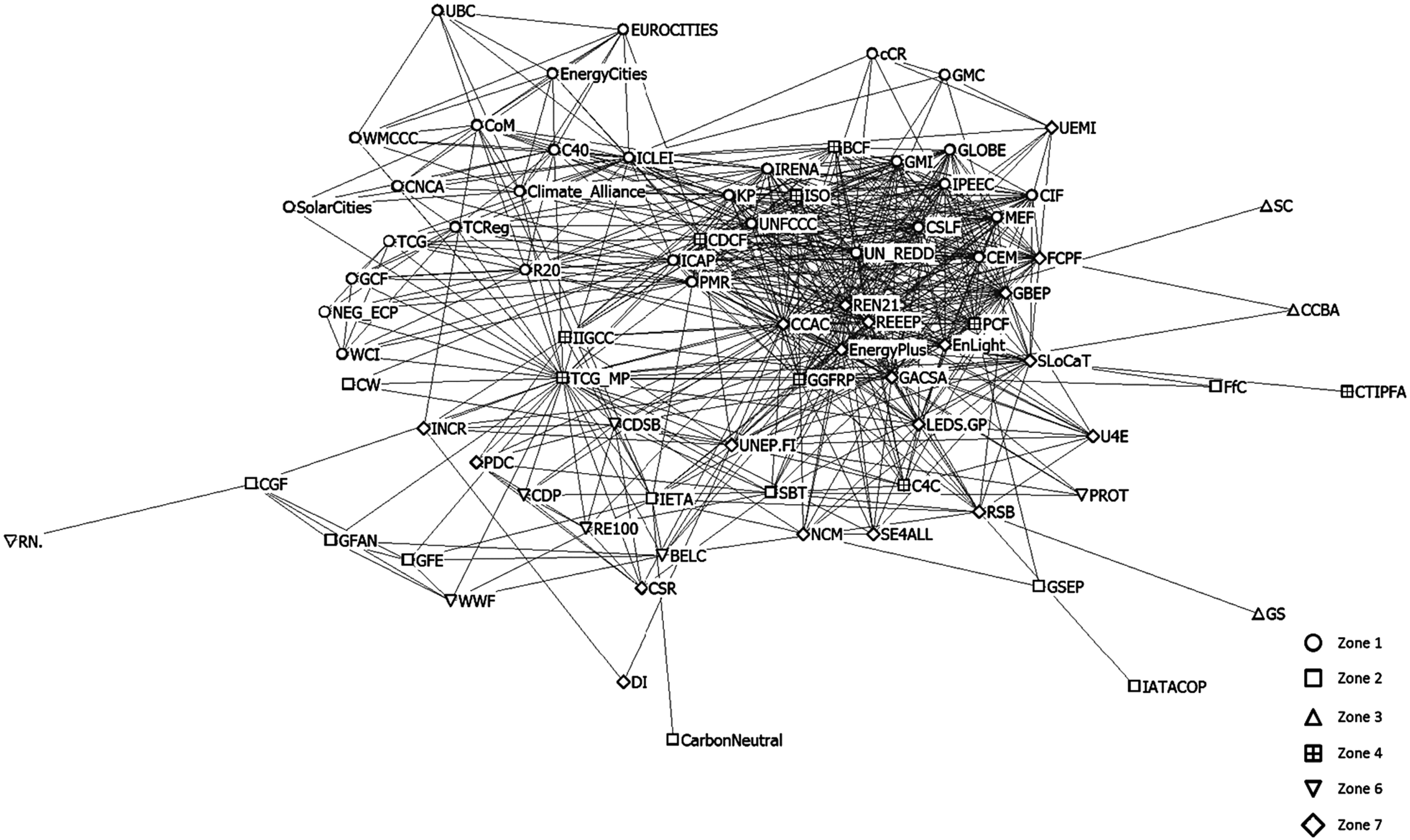

FIGURE 3.2: 1-mode membership network of institutions
(*source:* CONNECT)

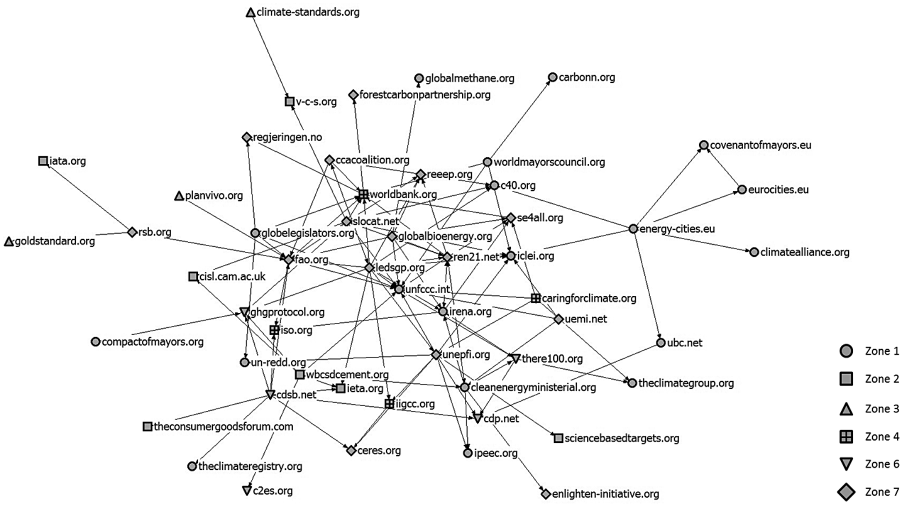

FIGURE 3.3: 1-mode hyperlink network of 53 institutions
(*source*: CONNECT)

Analysis (HNA)[48] and connecting institutions and organisations by homepages creates what have been referred to as Virtual Policy Networks (VPNs),[49] which are defined as web-based issue networks.[50] VPNs reflect the purposeful behaviour of one institution's attempt to publish information online and linking it to other institutions.[51]

In the context of complexity and 'interconnectedness', we are interested in the degree to which institutions connect to each other in cyberspace. To this end, an 'inter-actor' analysis has been conducted using Issue Crawler,[52] which requires a node to connect to another node from the list of starting points in order to be admitted to the network. As starting points, the homepages of the eighty-nine institutions in the CONNECT dataset have been used and tested at different depth, i.e. at how many iterations the harvesting of hyperlinks are carried out.[53] At the most conservative depth (1), only one iteration is performed collecting all the links at the sites of the starting homepages and checked for inter-actorness.

48 Park (2003).
49 McNutt (2010).
50 McNutt (2012); McNutt & Pal (2011).
51 McNutt (2012).
52 Rogers (2010).
53 Issuecrawler's instruction page provides a short explanation of crawl depth: 'The pages fetched from the starting point URLs are considered to be depth 0. The pages fetched from URL links from those pages are considered to be depth 1. In general, the pages found from URL links on a page of depth N are considered to be depth N+1. If you set a depth of 2, then no pages of depth 2 will be fetched. Only pages of depth 0 and 1 will be fetched (i.e. two levels of depth)' (www.govcom.org/Issuecrawler_instructions.htm).

The hyperlink network reaffirms the results in the membership and thematic networks of a highly dense and interlinked structure.[54] It suggests that institutions are actively engaging in trying to link with other institutions in the network, strengthening the observation that contemporary global climate governance is exercised in an intricate interaction structure.

The meaning behind linking homepages could be manifold. Homepages are places for institutions to send information to potential participants and users, and opportunities to show support or cooperation with other institutions. For instance, patterns in inward linking suggest that the system favours a few central hubs in terms of information and authority. Patterns in outward linking suggest that some institutions are trying to increase their own prestige and relevance by associating with certain institutions.

3.3.3 *Behavioural (Inter)dependence*

In networks, agents depend on the flows of resources, knowledge and norms. For instance, Kim[55] shows how nearly 750 multilateral environmental agreements connect in an increasingly interconnected dynamic network by referring to each other in the negotiated text. His findings suggest that the global body of international environmental law, in the absence of hierarchical coordination, has been self-organising into a 'mature' complex system.[56] Similarly, Green[57] has reported similar findings when linking private and public carbon accounting standards, revealing a hierarchical pattern in private accounting standards 'anchoring' to public international carbon accounting standards. Her findings show how agents create emergent behaviour in a system where different standards both compete and cooperate to carve out a niche.[58] The very concept of 'networked governance', contrasted against hierarchical or market governance, relies on these flows between agents and emergent interdependencies.

Within the CONNECT project, we have identified the central institutions that hold key positions in the network and therefore influence the flow of resources, knowledge and norms, thus creating forms of dependence. Figures 3.4 and 3.5 show two different measurements for identifying central institutions in the climate governance regime complex.

Figure 3.4 shows the centrality of institutions (highlighted in black) in terms of degree. Degree centrality is an indicator for institutions that have the most 'friends'. For flow of resources, however, an alternative measurement for centrality is more interesting, namely 'betweenness'. Betweenness centrality is an indicator for

[54] See Figure 3.3.
[55] Kim (2013).
[56] Ibid.
[57] Green (2013).
[58] Abbott, Green & Keohane (2015).

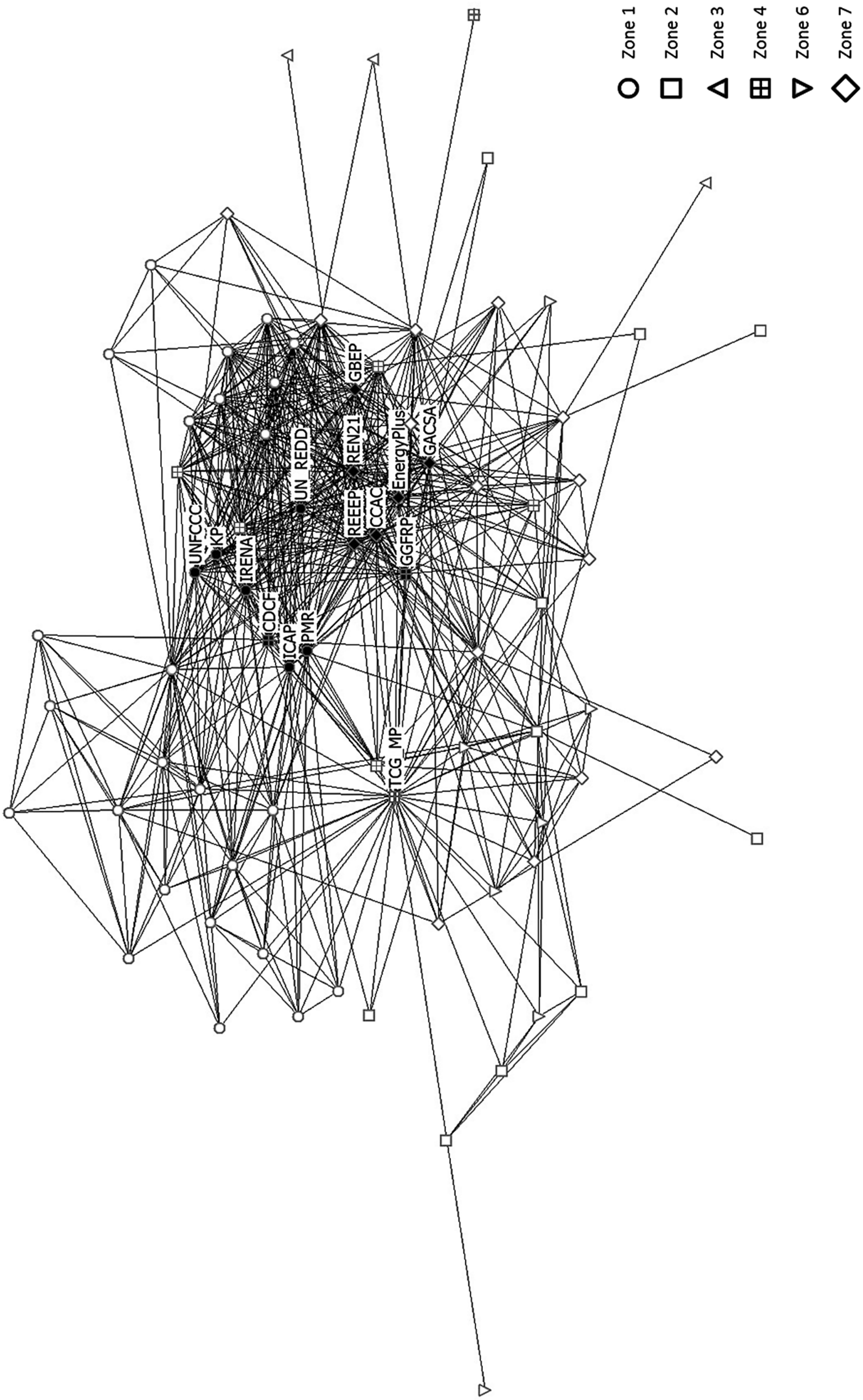

FIGURE 3.4: 1-mode membership network, 15 institutions with highest degree centrality in black (*source:* CONNECT)

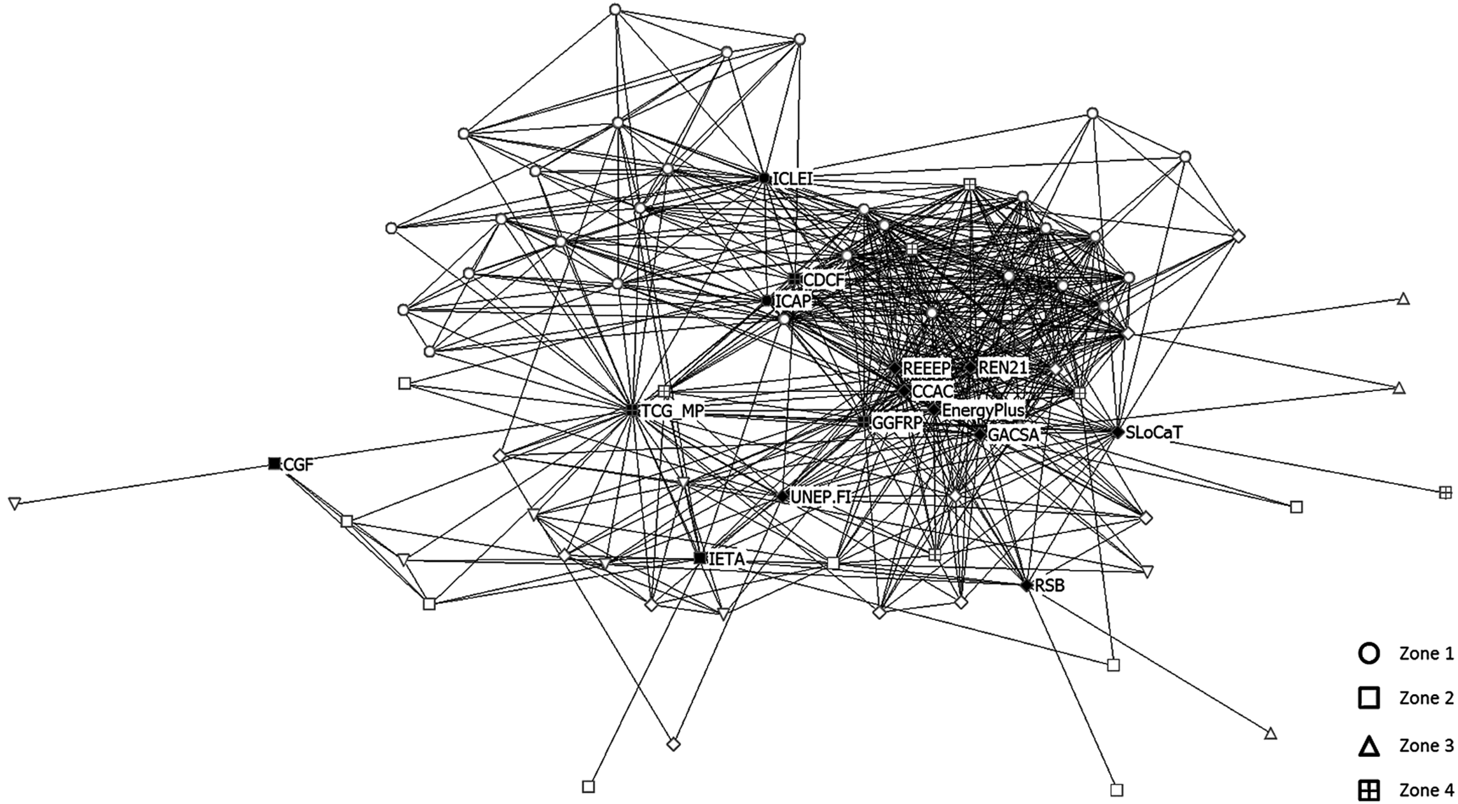

FIGURE 3.5: 1-mode membership network, 15 institutions with highest betweenness centrality in black (*source:* CONNECT)

institutions that are located between other institutions, having the possibility to act as gate-keepers for steering different flows. The behaviour of these institutions is thus in theory extremely important for ensuring efficient transfers of whatever that travels through the network. In Figure 3.5, the ten nodes with the highest betweenness centrality are highlighted in black. While there is some overlap between institutions with a high degree centrality and a high betweenness centrality, we find some nodes that only become important as potential gate-keepers.

The exercise in testing different measurement for centrality shows how the structural position of institutions becomes important when thinking of global governance in terms of complex systems and networks. In Figure 3.5, for example, we find that the institutions with the highest betweenness centrality are not international institutions such as the UNFCCC, but are rather those such as ICAP and REEEP, hybrid institutions that connect international and transnational institutions and public and private actors. These nodes are thus in theory important gate-keepers for the flow of resources, information and norms between – in particular – state and non-state actors.

3.3.4 *Openness*

As the fourth and final criterion for evaluating whether or not global climate change governance constitutes a complex system, we employ the idea of openness, meaning that a complex system should be interacting with its systemic environment (i.e. all other systems around it). Different from our approaches in Sections 3.3.2–3.3.4, openness cannot easily be measured in a quantitative way. Rather, we use qualitative data to illustrate that climate change indeed is an open system. Our main argument here is that the climate governance system is routinely interacting with other governance systems, exchanging resources, information and actors. Examples include governance in other policy fields that interacts with the climate change domain, such as the Montreal Protocol on Substances that deplete the Ozone Layer (as some Ozone-Depleting Substances (ODS) are also greenhouse gases), and climate change governance impacting on other policy domains, such as the UN REDD process and its relation to forest governance. A recent study on the institutional nexus between global biodiversity governance and other environmental policy fields[59] has shown that, for example, out of 385 institutions governing climate change, agriculture, fisheries and forests, 108 institutions also have governance functions related to biodiversity. Similar studies on the Sustainable Development Goals have shown that the seventeen individual goals are connected by both bio-physical links and institutional interactions.[60] In sum, the climate change governance architecture is not only rich with internal

[59] Pattberg, Kristensen & Widerberg (2017).
[60] Boas, Biermann & Kanie (2016); Nilsson, Griggs & Visbeck (2016).

interactions and behavioural linkages (Sections 3.3.1–3.3.3) but also with linkages to other policy fields, both environmental and non-environmental.

3.4 IMPLICATIONS FOR SMART MIXES AND THE WAY FORWARD

This chapter has argued that learning from complexity theory offers new insights into the system of global environmental governance. In fact, we have attempted to demonstrate that some global governance systems, in this case the global climate governance architecture, are complex systems and can therefore be analysed from a complexity perspective.

Concluding that the current climate change governance architecture displays properties of a complex system has at least three important implications for the idea of 'smart mixes'. First, following from the insight that in complex systems the whole is greater than the sum of its parts, studying individual governance arrangements and ideal-types is insufficient for understanding the actual behaviour of the evolving regime complex. Instead, actors and interactions must be studied taking their broader environment, context and position within an interaction network into account. In this chapter, we have illustrated how mapping a governance system using network-based approaches could help research further in positioning events in their broader contexts.

Second, since non-linear behaviour is the rule rather than the exception, complex systems need different evaluation criteria than simple or complicated systems. Using concepts from complexity theory to open up the 'black box' between input and impacts of interventions in a policy field – for instance, by using complex program theory[61] – could improve our understanding of observed social change or how to more effectively reach governance goals.[62] For example, conventional linear thinking on how to bring about change is challenged if we understand outcomes as emergent rather than being planned, or the functioning of feedback loops in social systems to create large changes with small means.

And third, and related to the previous point, a complex systems perspective calls into question overly positive expectations about orchestration and the ability of actors to influence the system in a linear-causal way. While individual cooperative initiatives in the climate change policy field might well be considered as 'orchestrated', the overall system is not the result of rational planning. Feedbacks and unintended consequences (both positive and negative) undermine the linear-consequential ontology of orchestration. From this vantage point, the question of smart mixes is a relevant *ex ante* evaluation but less important in the design or planning phase.

Finally, we see in particular three areas for future research. First, efforts should be made to better measure and explain varying degrees of complexity across various

[61] Rogers (2008).
[62] Stame (2004).

issue areas and policy domains in a comparative perspective. Understanding governance systems as complex systems allows for a unified theoretical perspective on seemingly disparate phenomena in world politics, from migration to climate change, the financial system and sustainable development. A second challenge and research opportunity lies in modelling complex governance systems. The guiding question here is whether we can foresee (within certain margins of uncertainty) the evolution of complex governance systems. For example, would we rather expect increased synergies and integration, or fragmentation and welfare losses? This means that we make a step closer to modelling smart mixes as an outcome of complex systems. And third, we should make more efforts to accommodate failure into our theorising. Complexity theory could be used to better understand governance failures as well as adaptive behaviour of governance systems. From this perspective, designing smart mixes is not so much rational planning as constant experimenting, failing, adapting and learning. We hope that a complexity perspective can help to balance overly optimistic and technical approaches towards planning policy interventions.

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